ACOUSTICS AND AIR

SHORE PHYSICAL EDUCATION CENTRE
SHORE, NORTH SYDNEY
DEVELOPMENT APPLICATION
CONSTRUCTION & OPERATIONAL NOISE REPORT

REPORT NO. 16150
VERSION B

JULY 2016

PREPARED FOR

SYDNEY CHURCH OF ENGLAND GRAMMAR SCHOOL (SHORE)
C/- EPM PROJECTS
5/655 PACIFIC HWY
ST LEONARDS NSW 2065

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DOCUMENT CONTROL

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A	Final	2 June 2016	Brian Clarke	JW
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TABLE OF CONTENTS

GLOSSARY OF ACOUSTIC TERMS

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors, which are demonstrated in the graph below, are here defined.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

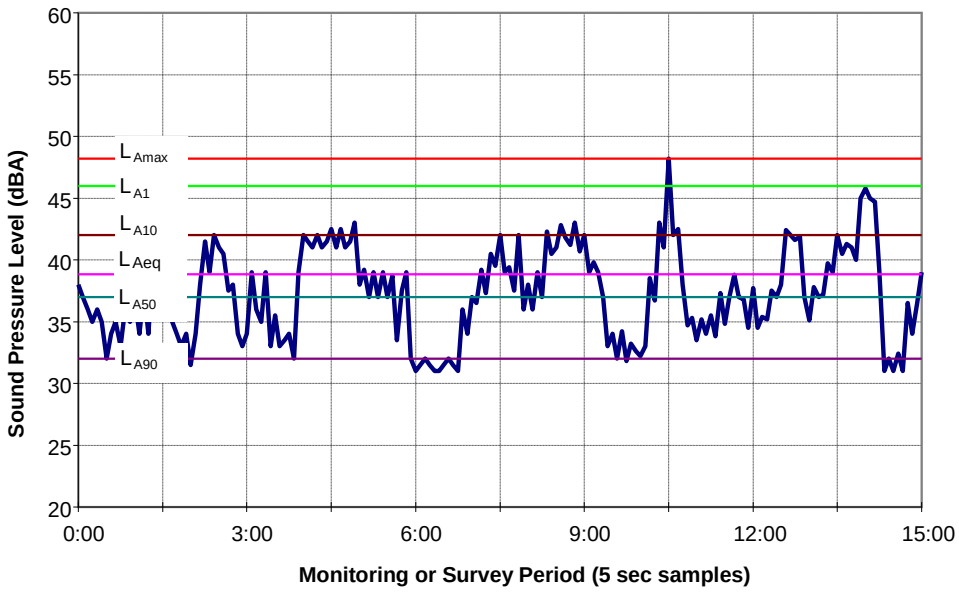
L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10th percentile (lowest 10th percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.

Typical Graph of Sound Pressure Level vs Time



1 INTRODUCTION

This Noise Impact Assessment (NIA) has been prepared on behalf of Sydney Church of England Grammar School ("the Proponent"). It accompanies an Environmental Impact Statement (EIS) prepared in support of State Significant Development Application SSD 7507 for the development of the Shore Physical Education Centre at North Sydney.

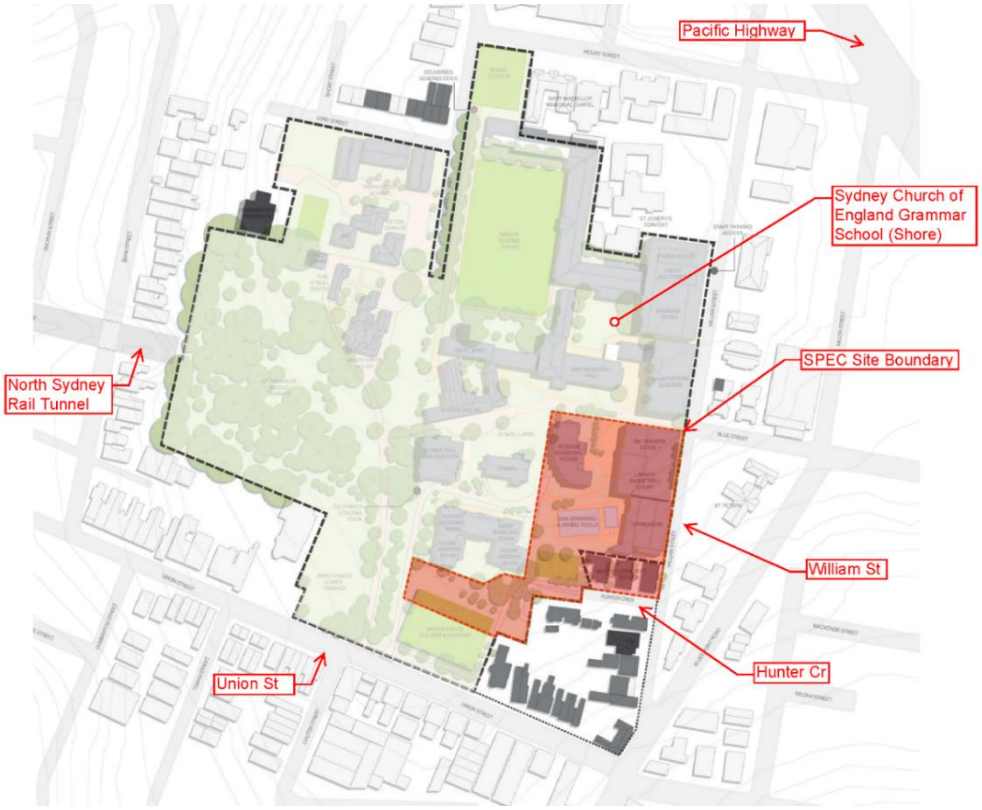
1.1 Development Details

The Shore Physical Education Centre ('SPEC') is a development planned for the Sydney Church of England Grammar School at Blue Street, North Sydney. The proposed development includes:

1. Demolition of the existing 1970s 25m swimming pool and associated structures, gymnasium, change rooms, weights room, two squash court etc., in the south-eastern corner of Shore Senior School and the residential flat buildings at 4 and 5 Hunter Crescent and 16 William Street.
2. Construction of new buildings to be known as the SPEC and alterations / additions to existing buildings comprising:
    a) Aquatic Centre accommodating a 50m indoor swimming pool (eight lanes);
    b) Multi-purpose Sporting Complex, including three basketball courts with tiered seating, gymnasium, weights rooms and other training facilities, change rooms, reception area, staff facilities and amenities;
    c) 11 new classrooms, flexible learning spaces, seminar rooms, other teaching and staff spaces;
    d) Alterations to BH Travers Stage 1, including change room and other upgrades;
    e) A net increase of 38 car parking spaces; and
    f) Loading facilities on the ground floor of the proposed SPEC.
3. New open spaces / courtyards, tree removal / replacement and landscaping of the site, including landscaped roof terraces.
4. Use of the completed buildings as an educational establishment including extension of Shore onto 4 and 5 Hunter Crescent and 16 William Street.

The existing College and proposed development location is shown in Figure 1-1.

Figure 1-1 Existing Site Plan



The location of the new buildings on the site are shown in Figure 1-2. The site is bounded by multi-level residences on the southern and eastern sides.

Figure 1-2 Proposed Site

Wilkinson Murray Pty Limited has reviewed and assessed the drawings and relevant documentation prepared in respect of this State Significant Development (SSD 7507) submission.

The NIA details established site-specific noise and vibration criteria in accordance with the following SEAR requirements:

8. Noise and Vibration

Identify and provide a quantitative assessment of the main noise and vibration generating sources during construction and operation. Outline measures to minimise and mitigate the potential noise impacts on surrounding occupiers of land.

Relevant Policies and Guidelines:

- NSW *Industrial Noise Policy* (EPA)
- *Interim Construction Noise Guideline* (DECC)
- *Assessing Vibration: A Technical Guideline 2006*

2 AMBIENT NOISE LEVELS AT SITE

Residential receivers surrounding the site that may be affected by construction and operational noise have been identified in two areas and are detailed in Table 2-1 and are shown in Figure 2-1.

Figure 2-1 Aerial showing Noise Monitoring Locations

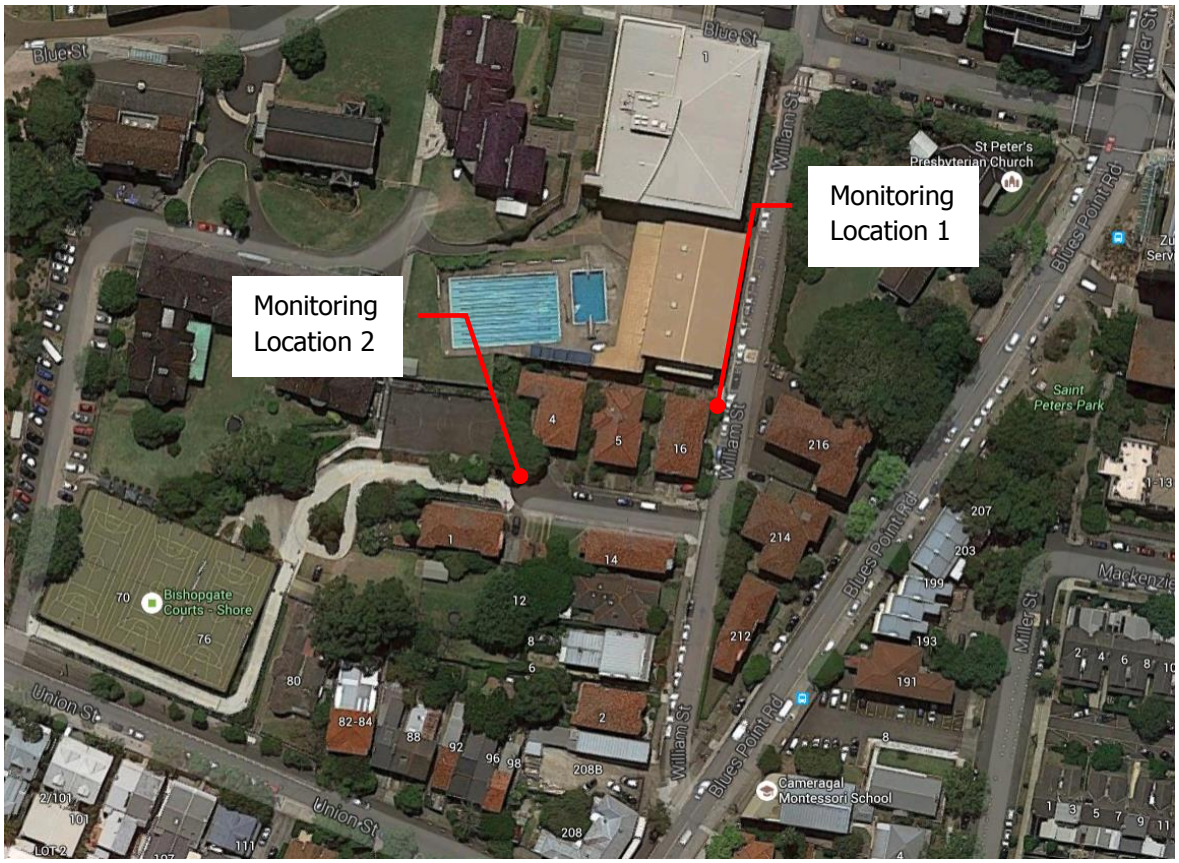


Table 2-1 Surrounding Receivers

Receivers	Comments
A – William Street	Multi storey residential buildings.
B – Hunter Crescent	Multi storey residential buildings.
C – Union Street	Single Residential buildings

In order to quantify the existing noise environment, long-term ambient noise levels were monitored at two (2) locations surrounding the site, selected to cover the range of environments in the potentially affected areas.

The noise logger locations are presented in Table 2-2 and are shown in Figure 2-1.

Table 2-2 Long-Term Noise Monitoring Locations

Logger	Location	Monitoring Period
1	16 William Street	10 – 17 May 2016
2	4 Hunter Crescent	10 – 17 May 2016

The noise monitoring equipment used for the Wilkinson Murray noise measurements consisted of ARL Type EL-215 environmental noise loggers set to A-weighted, fast response, continuously monitoring over 15-minute sampling periods. This equipment is capable of remotely monitoring and storing noise level descriptors for later detailed analysis. The equipment calibration was checked before and after the survey and no significant drift was noted.

The logger determines L_{A1}, L_{A10}, L_{A90} and L_{Aeq} levels of the ambient noise. L_{A1}, L_{A10} and L_{A90} are the levels exceeded for 1%, 10% and 90% of the sample time respectively (see Glossary for definitions). The L_{A1} is indicative of maximum noise levels due to individual noise events such as the occasional pass-by of a heavy vehicle. The L_{A90} level is normally taken as the background noise level during the relevant period.

Detailed results for each monitoring location are shown in graphical form in Appendix A. The graphs show measured values of L_{Aeq}, L_{A90}, L_{A10} and L_{A1} for each 15-minute monitoring period.

Table 2-3 summarises the noise results, for daytime, evening and night time periods as defined in the EPA's *Interim Construction Noise Guidelines (ICNG)* and the NSW *Industrial Noise Policy (INP)*. Additionally, noise monitoring results for Saturday (7.00am-5.00pm) have been included as construction is proposed outside standard hours.

Table 2-3 Summary of Measured Ambient Noise Levels

Noise Logging Site	RBL (dBA)				$L_{Aeq,period}$ (dBA)			
	Daytime 7am-6pm	Evening 6-10pm	Night Time 10pm-7am	Saturday 7am-6pm	Daytime 7am-6pm	Evening 6-10pm	Night Time 10pm-7am	Saturday 7am-6pm
1	49	44	39	49	57	54	50	58
2	45	43	41	45	52	49	46	52

Since it is proposed that some activities at the school would commence at 6.00am, it is also necessary to determine the RBL during the 6.00am-7.00am shoulder period. This is shown in Table 2-4.

Table 2-4 RBL during Morning Shoulder Period (6am-7am)

Noise Logging Site	RBL (dBA) 6am-7am
1	42
2	43

Background noise levels at all locations were free of the influence of extraneous noise sources, such as plant or construction activities. Noise data measured during inclement weather was reviewed in accordance with EPA procedures.

Noise levels measured at Hunter Crescent have also been used for the more remote residences in Union Street. These levels are considered a conservative representation of ambient noise levels in Union Street.

3 CONSTRUCTION NOISE & VIBRATION ASSESSMENT

This section of the assessment construction impacts with respect to noise and vibration.

3.1 Construction Noise Criteria

The following sections detail the applicable site-specific noise and vibration criteria based on the EPA *Interim Construction Noise Guideline*.

3.1.1 Construction Noise Management Levels

The EPA released the "*Interim Construction Noise Guideline*" *(ICNG)* in July 2009. The guideline provides noise goals that assist in assessing the impact of construction noise.

For residences, the basic daytime construction noise goal is that the $L_{Aeq,\ 15min}$ noise management level should not exceed the background noise by more than 10dBA. This is for standard hours: Monday to Friday 7.00am-6.00pm, and Saturday 8.00am-1.00pm. Outside the standard hours, where construction is justified, the noise management level would be background + 5dBA. Table 3-1 details the *ICNG* noise management levels.

Table 3-1 Construction Noise Management Levels at Residences using Quantitative Assessment

Time of Day	Management Level $L_{Aeq,(15min)}$	How to Apply
Recommended Standard Hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or Public Holidays	Noise affected RBL + 10dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq,(15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.

Time of Day	Management Level $L_{Aeq,(15min)}$	How to Apply
Outside recommended standard hours	Noise affected RBL + 5dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2.

In addition, the following construction noise management levels $L_{Aeq,15min}$ are recommended for other receivers and areas.

- Active recreation areas (such as parks): external $L_{Aeq,15min}$ 65dBA
- Industrial premises: external $L_{Aeq,15min}$ 75dBA
- Offices, retail outlets: external $L_{Aeq,15min}$ 70dBA
- Classrooms at schools and other educational institutions: internal $L_{Aeq,15min}$ 45dBA

Based on the above, Table 3-2 presents the applicable noise management levels for construction activities at surrounding receivers that have been adopted for all applications.

Table 3-2 Site-Specific Construction Noise Management Levels

Area	Construction Noise Management Level, L_{Aeq} – dBA				Highly noise affected Noise Level, L_{Aeq} dBA
	Day	Evening	Night	Saturday*	
A – William Street	59	49	44	54	75
B – Hunter Crescent	55	48	46	50	75
C – Union Street**	55	48	46	50	75

* Extended Saturday construction hours.
** The lower noise criteria have been applied at residences on Union Street.

3.2 Hours of Operation & Programme

The proposed working hours for this project are as follows:

- Monday to Friday 7.00am to 7.00pm
- Saturdays 7.00am to 5.00pm
- Sundays and Public Holidays No work

If required, after hours permits will be sought from the relevant authorities.

3.3 Vibration Criteria

Criteria for assessment of the effects of vibration on human comfort are set out in British Standard 6472-1992. Methods and criteria in that Standard are used to set "preferred" and "maximum" vibration levels in the document "*Assessing Vibration: A Technical Guideline*" (2006) produced by the NSW EPA.

Acceptable values of human exposure to continuous vibration, such as that associated with drilling, are dependent on the time of day and the activity taking place in the occupied space (e.g. workshop, office, residence or a vibration-critical area). Guidance on preferred values for continuous vibration is set out in Table 3-3.

Table 3-3 Criteria for Exposure to Continuous Vibration

Place	Time	Peak Particle Velocity (mm/s)	
		Preferred	Maximum
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.14	0.28
Residences	Daytime	0.28	0.56
	Night time	0.20	0.40
Offices	Day or night time	0.56	1.1
Workshops	Day or night time	1.1	2.2

In the case of intermittent vibration, which is caused by plant, such as rock breakers, the criteria are expressed as a Vibration Dose Value (VDV) and are presented in Table 3-4.

Table 3-4 Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime		Night Time	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Calculation of VDV requires knowledge of the number of events, and their duration in the relevant time period.

3.3.1 Building Damage

In terms of the most recent relevant vibration damage objectives, Australian Standard AS 2187: Part 2-2006 *"Explosives – Storage and Use – Part 2: Use of Explosives"* recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 *"Evaluation and measurement for vibration in buildings Part 2"*, as they "are applicable to Australian conditions".

The British Standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

The recommended limits (guide values) from BS7385 for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 3-5.

Table 3-5 Transient Vibration Guide Values – Minimal Risk of Cosmetic Damage

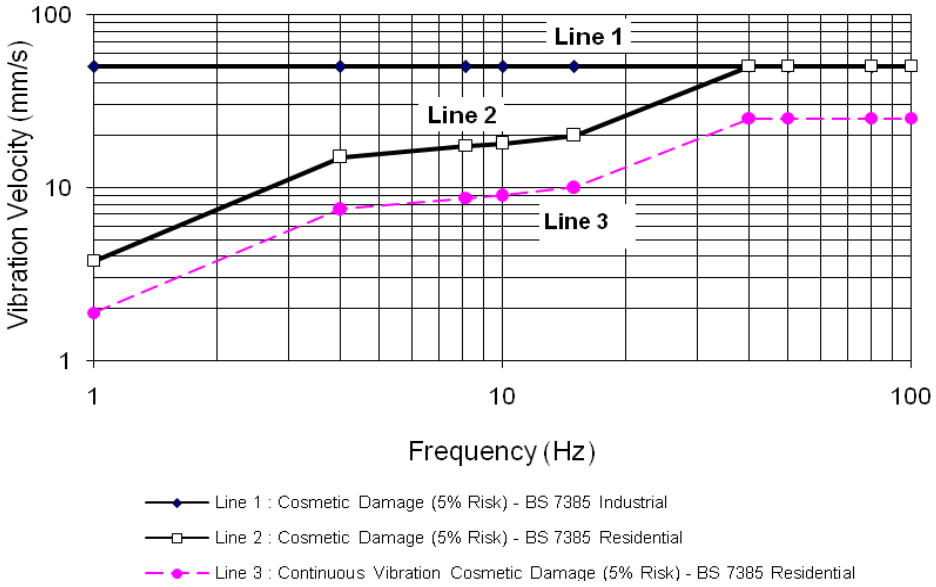
Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50mm/s at 4 Hz and above	N/A
Un-reinforced or light framed structures Residential or light commercial type buildings	15mm/s at 4 Hz increasing to 20mm/s at 15 Hz	20mm/s at 15 Hz increasing to 50mm/s at 40 Hz and above

The Standard states that the guide values in Table 3-5 relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings.

Note that rock breaking / hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures (e.g. residences) and it may therefore be appropriate to reduce the transient values by 50%.

The British Standard goes on to state that "*Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity*". In addition, a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive.

Figure 3-1 Graph of Transient Vibration Guide Values for Cosmetic Damage



In addition to the British Standard, for the case of nearby heritage buildings, guidance for structural damage is derived from the German Standard DIN 4150 -3 *"Structural Vibration Part 3 – Effects of Vibration on Structures"*. The following Table 3-6 details these recommendations for heritage buildings.

Table 3-6 DIN 4150 recommend PPV vibration level for Heritage Buildings

Guideline Values for Velocity – mm/s		
1 to 10 Hz	10 to 15 Hz	40 to 50 Hz
3	3 to 8	8-10

3.4 Construction Equipment & Noise Source Levels

Sound Power Levels (SWLs) for typical construction plant are identified in Table 3-7. These SWLs have been measured at other similar construction sites. The table gives both Sound Power Level and Sound Pressure Levels (SPL) at 7m for the equipment. Sound Power Level is independent of measurement position.

Table 3-7 Typical Construction Plant Sound Levels – dBA

Plant	Sound Power Level	Sound Pressure Level at 7m
Concrete Truck	109	84
Angle Grinder	109	84
Concrete Pump – 120 mm diameter / 50 bar	112	87
Concrete Saw	116	91
Mobile Crane	98	73
Dump Truck	108	83
Compressor	100	75
Bobcat	103	78
Hand Tools	90	65
Excavator	108	83
Crawler Cranes	98	73
Tower Crane	104	79
Front End Loader	112	87
Excavator	107	82
Hammer Hydraulic	122	97
Bored Pile Rig	112	87

3.5 Construction Noise Predictions

Assessment of possible construction noise at surrounding receivers has been undertaken for the proposed construction works.

Site-related noise emissions were modeled with the "CadnaA" noise prediction program, using the ISO 9613 noise prediction algorithms. Factors that are addressed in the noise modeling are:

- equipment sound level emissions and location;
- screening effects from buildings;
- receiver locations;
- ground topography;
- noise attenuation due to geometric spreading;
- ground absorption; and
- atmospheric absorption.

Modelling has been conducted for a number of construction scenarios with plant located across the construction site. The three works scenarios considered are summarised in Table 3-8.

Table 3-8 Construction Scenarios for Construction Works

Scenario	Description	Works
A	Bulk Excavation	Bulk Excavation in rock – excavation using rock saw, ripping using excavator mounted claws. Bulk Excavation other than rock (OTR) – mainly using excavators used to breakdown large rock elements. Truck Movements – loaded into trucks sent off site.
B	Building Construction	This scenario includes concreting and lifting. 1 concrete pump, 2 forklifts, 1 compressor, 1 crane, a boom truck and tower crane are assumed to operate in 15 minutes. Also concrete trucks and normal delivery trucks assumed to be two movements in 15 minutes.
C	Façade / Fitout	In the event that the construction of the facade occurs in isolation. Forklift, truck, tower crane and power tools assumed. Two truck movements in 15 minutes assumed.

The construction noise modelling assumes a "typical worst-case" scenario whereby all plant, is running continuously. As such, the modelling represents likely noise levels that would occur during intensive periods of construction. Therefore, the presented noise levels can be considered in the upper range of noise levels that can be expected at surrounding receivers when the various construction scenarios occur.

Once noise sources have been applied to the model, the resultant noise levels at identified surrounding receivers are predicted. These results are then compared with established site-specific noise criteria.

The results of construction noise modelling for each scenario are presented in Table 3-9.

Table 3-9 Predicted Construction Noise Levels at Residence – $L_{Aeq(15\ min)}$ – dBA

Residential Receiver	Predicted Noise Level	Weekday NML*	Exceedance	Sat NML	Exceedance
Scenario A – Bulk Excavation (with Rock)					
A – William Street	68	59	9	54	14
B – Hunter Crescent	71	55	16	50	21
C – Union Street	56	55	1	50	6
***Scenario B* – Building Construction**					
A – William Street	63	59	4	54	
B – Hunter Crescent	66	55	9	50	16
C – Union Street	54	55	-	50	4
Scenario C – Façade / Fitout					
A – William Street	58	59	-	54	4
B – Hunter Crescent	58	55	3	50	8
C – Union Street	45	55	-	50	-

A review of results of construction noise indicates that these may be well above construction noise management levels at nearby residences particularly in areas A and B (which are the residences close to the construction site), during excavation and construction stages. On Saturdays, the exceedance is likely to be greater for extended construction hours.

3.6 Discussion of Results

Exceedances of noise management levels of up to 21 dBA at residences to the south of the site may be expected during excavation period when major equipment is located on site. This magnitude of exceedance is consistent with similar sites where residences overlook development sites.

During the structure and fitout stages the magnitude of exceedance will reduce due to the nature of construction activities.

Greater exceedances are predicted on Saturdays due to more stringent noise management levels that are triggered by the proposed extended hours of operation on this day.

Based on these findings the adoption of reasonable and feasible noise management and mitigation will be required. These measures should be determined in detail when a contractor, with defined construction techniques, has been engaged on the project. However, "in-principle" mitigation measures are detailed in the following sections.

3.7 Construction Vibration Assessment

Operation of rock breakers and the like generate ground vibration that has the potential to transmit to nearby buildings. Table 3-10 sets out the typical ground vibration levels at various distances for safe working distances.

Table 3-10 Recommended Safe Working Distances for Vibration-Intensive Plant

Item	Description	Safe Working Distance	
		Cosmetic Damage	Human Response
Small Hydraulic Hammer	(300 kg – 5 to 12t excavator)	2m	7m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7m	23m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22m	73m
Vibratory Pile Driver	Sheet piles	2m to 20m	20m
Pile Boring	≤ 800 mm	2m (nominal)	N/A
Jackhammer	Hand held	1m (nominal)	Avoid contact with structure

· Construction Noise Strategy, 2012, Transportation Construction Authority.

The highest vibration levels will occur when construction equipment is located on the eastern side of the site near residences on the eastern boundary.

A review of the site plant and surrounding receivers indicates that the minimum distance between the vibration generating activities and surrounding buildings will be in the order of 3-4m. Therefore, the use of medium to large rock breakers should be carefully managed at distances closer than 20m from residences.

It is recommended that trial testing of vibration levels be conducted where identified equipment having the potential to exceed the human comfort criteria is proposed.

Structural damage vibration criteria in residential buildings are much higher than human comfort criteria, and predicted vibration levels are within these criteria under most circumstances. The exception, should heavy rock breakers be used, is for areas near residences on William Street and Hunter Crescent. Therefore, the uses of alternative excavation measures, such as rock saws on excavators are recommended. If hammers are required, test vibration monitoring is recommended to ensure that vibration levels at residences are not excessive.

3.8 Railway Easement

The North Shore rail easement is located close to the construction site. Therefore, Sydney Trains will have vibration criteria that must not be exceeded during construction works. Therefore, the principal contractor will need to assess potential vibration levels at the easement and compare these with established criteria.

If warranted the contractor may need to install vibration monitors and conduct trial testing of equipment such as rock breakers. The detail of these investigations should form part of the project noise and vibration management plan.

3.9 Construction Noise & Vibration Mitigation Measures

Without mitigation, noise levels from construction activities have been predicted to exceed the noise management levels nominated in the guidelines at some surrounding receivers. Therefore, noise control measures are recommended to ensure that noise is reduced where feasible.

The following project-specific mitigation measures are recommended:

- Installation of a 2.4m plywood hoarding around the construction site;
- Selection of quietest feasible construction equipment;
- Use of rock saws and ripping in preference to rock breakers;
- Localised treatment, such as barriers, shrouds and the like around fixed plant, such as pumps, generators and concrete pumps;
- Provision of respite periods, particularly on Saturdays;
- Trial testing of vibration levels is conducted where equipment is identified as having the potential to exceed the human comfort criteria; and
- Assessment of vibration impact on the rail easement and selection of appropriate distance and equipment to be used in excavation in the vicinity of the rail easement.

In addition, the following measures should be included in a Noise & Vibration Management Plan.

- *Plant Noise Audit* – Noise emission levels of all critical items of mobile plant and equipment should be checked for compliance with noise limits appropriate to those items prior to the equipment going into regular service. To this end, testing should be established with the contractor.
- *Operator Instruction* – Operators should be trained in order to raise their awareness of potential noise problems and to increase their use of techniques to minimise noise emission.
- *Equipment Selection* – All fixed plant at the work sites should be appropriately selected, and where necessary, fitted with silencers, acoustical enclosures and other noise attenuation measures in order to ensure that the total noise emission from each work site complies with EPA guidelines.
- *Site Noise Planning* – Where practical, the layout and positioning of noise-producing plant and activities on each work site should be optimised to minimise noise emission levels.

The adoption of the above measures are aimed at working towards achieving the noise management levels established at surrounding receivers.

3.10 Community Liaison & General Approaches to Mitigation

An effective community relations programme should be put in place to keep the community that has been identified as being potentially affected appraised of progress of the works, and to forewarn potentially affected groups (e.g. by letterbox drop, meetings with surrounding owners / tenants, etc.) of any anticipated changes in noise and vibration emissions prior to critical stages of the works, and to explain complaint procedures and response mechanisms. This programme should include a *Community and Stakeholder Engagement Strategy* developed specifically for the Project which will be managed by the Principal Contractor.

Close liaison should be maintained between the communities overlooking work sites and the parties associated with the construction works to provide effective feedback in regard to perceived emissions. In this manner, equipment selections and work activities can be coordinated where necessary to minimise disturbance to neighbouring communities, and to ensure prompt response to complaints, should they occur.

3.11 Noise & Vibration Management Plan

A construction Noise & Vibration Management Plan for the site is recommended which should be prepared by the successful contractor. The plan should reference the findings of this assessment. Areas that should be addressed in plan include:

- noise and vibration mitigation measures;
- noise and vibration monitoring;
- response to complaints**;**
- responsibilities;
- monitoring of noise emissions from plant items;
- reporting and record keeping;
- non-compliance and corrective action; and
- community consultation and complaint handling.

4 OPERATIONAL NOISE & VIBRATION

Operational noise from the proposed facilities will be generated by activities within the new buildings and mechanical plant located predominantly in the basement or near the new carpark.

4.1 Operational Noise Criteria

Noise impact from the general operation of the proposed facilities is to be assessed with respect to the site-specific noise criteria based on site monitoring and the NSW *Industrial Noise Policy (INP).* The assessment procedure in terms of the *INP* has two components:

- Controlling intrusive noise impacts in the short-term for residences; and
- Maintaining noise level amenity for particular land uses for residences and other land uses.

The *NSW Industrial Noise Policy (INP)* recommends two criteria, "Intrusiveness" and "Amenity", both of which are relevant for the assessment of noise. In most situations, one of these is more stringent than the other and dominates the noise assessment. The criteria are based on the L_{Aeq} descriptor, which is explained in the glossary.

4.1.1 Intrusiveness Noise Criterion

The intrusiveness criterion requires that the L_{Aeq} noise level from the source being assessed, when measured over 15 minutes, should not exceed the Rating Background Noise Level (RBL) by more than 5dBA. The RBL (as presented in Table 2-3 for each long-term monitoring site) represents the 'background' noise in the area, and is determined from measurement of L_{A90} noise levels, in the absence of noise from the source. The definition of L_{A90} and the procedure for calculating the RBL is presented in the glossary.

An intrusiveness criterion applies for residential receivers only.

4.1.2 Amenity Noise Criterion

The amenity noise criterion sets a limit on the total noise level from *all industrial noise sources* affecting a receiver. Different criteria apply for different types of receiver (e.g. residence, school classroom); different areas (e.g. rural, suburban); and different time periods, namely daytime (7.00am-6.00pm), evening (6.00pm-10.00pm) and night time (10.00pm-7.00am).

The noise level to be compared with this criterion is the L_{Aeq} noise level, measured over the time period in question, due to all industrial noise sources, but excluding non-industrial sources, such as transportation.

Where a new noise source is proposed in an area with negligible existing industrial noise, the amenity criterion for that source may be taken as being equal to the overall amenity criterion. However, if there is significant existing industrial noise, the criterion for any new source must be set at a lower value. If existing industrial noise already exceeds the relevant amenity criterion, noise from any new source must be set well below the overall criterion to ensure that any increase in noise levels is negligible. Methods for determining a source-specific amenity criterion where there is existing industrial noise are set out in the *INP.*

4.1.3 Determination of Project-Specific Noise Criteria

The intrusiveness criteria for each surrounding residential receiver area are presented in Table 4-1. This was calculated by adding 5dB to the RBL of the nearest long term monitoring location, as discussed in Section 4.1.1 above.

Table 4-1 Intrusive Noise Criteria

Location	Intrusiveness Criterion $L_{Aeq,15min}$ (dBA)			
	Daytime 7am-6pm	Evening 6pm-10pm	Night Time 10pm-7am	Morning Shoulder 6am-7am
A – William Street	54	49	44	47
B – Hunter Crescent	50	48	46	48
C – Union Street	50	48	46	48

For this assessment, all residential receivers were considered as 'Suburban' in line with the *INP*. Given our observations on and around site, noise at all locations is dominated by general traffic or urban hum, and other sources that are not classified as industrial. As such, it has been assumed that the $L_{Aeq,period}$ from industrial noise is more than 10dB below the designated amenity criterion during any time period. Therefore, no correction to the amenity criteria is warranted. The amenity criteria for each receiver are presented in Table 4-2.

Table 4-2 Amenity Criteria

Location	Type of Receiver	Amenity Criterion $L_{Aeq,period}$ (dBA)		
		Daytime 7am-6pm	Evening 6pm-10pm	Night Time 10pm-7am
All Residences	Residential	55	45	40
Commercial Receivers	Commercial	65	65	65

Intrusiveness noise criteria are expressed in terms of $L_{Aeq,15min}$, whereas amenity criteria are in terms of $L_{Aeq,Period}$. The $L_{Aeq,Period}$ levels are typically lower than $L_{Aeq,15min}$ levels, however, for noise from continuously-operating mechanical plant this difference is small, as such the $L_{Aeq,15min}$ will be used as the noise descriptor for project. The lowest of the intrusive and the amenity criteria are then used as project specific noise criteria for the site and are presented in Table 4-3.

Table 4-3 Project-Specific Noise Criteria

Site	Site-Specific Noise Criteria $L_{Aeq,15min}$ (dBA)			
	Daytime 7am-6pm	Evening 6pm-10pm	Night Time 10pm-7am	Morning Shoulder 6am-7am
A – William Street	54	45	40	47
B – Hunter Crescent	50	45	40	48
C – Union Street	50	45	40	48
Commercial Receivers	65	65	65	65

4.2 Operational Mechanical Noise Assessment

The major mechanical noise sources associated with the development will be carpark exhaust fans and plant that will be located in the lower levels of the new buildings. In addition, a ground level cooling tower enclosure is proposed between the new buildings and the existing courts on Union Street as shown in Figure 4-1.

Figure 4-1 Proposed Cooling Towers Location

Noise from most major plant, such as chillers, fan coil units and pumps will be contained by the building structure. Therefore, it is the cooling tower and fans that may require noise mitigation to achieve the established site-specific noise criteria at surrounding receivers.

Detailed specifications of mechanical services equipment that would otherwise allow an acoustic assessment of noise emissions from the site are not available at this stage of the project as selection and design is conducted after project approval.

In line with the approvals for other developments, detailed assessment of operational noise emission should form a conditional requirement of the development, to be satisfied to the PCA, prior to the issue of the construction certificate.

To mitigate noise from mechanical plant, it is likely the some or all of the following noise control measures may need to be adopted at the design stage to meet noise objectives:

- Silencers on carpark and other fans,
- Acoustic louvres,
- Noise barriers, and;
- Variable speed controls on cooling towers.

The mechanical plant will be designed to meet the criteria presented in Table 4-3 at the identified nearby receivers.

4.3 Sporting Activities & Events

4.3.1 Sports Hall

The proposed new Sports Hall includes a gymnasium at lower ground level, weights area at ground level, basketball courts at levels 1 and 2 and classrooms at level 3. The building will comprise a combination glass (fixed minimum 10.38mm laminate assumed), facebrick and metal panel facade construction and a metal deck roof.

Existing sporting events currently held in other areas of the College (existing gym and existing weights area) will be held within the new Sports Hall. In terms of operational noise, the highest noise-generating area will be the level 1 and 2 basketball courts. Maximum reverberant sound pressure levels of around 95dBA can be expected to be reached during large scale competitions (including whistles, PA and hooter). An L_{Aeq} over 15 minutes of around 83dBA (reverberant sound pressure level) is typical during college basketball games.

In order to assess the potential operational noise emissions from the proposed Sports Hall, a large attendance, competitive basketball event has been adopted as representative of a worst case operational scenario.

Assuming a reverberant sound pressure level of 83dBA to 85dBA within level 1, the predicted $L_{Aeq,15min}$ at the potentially most exposed residential recievers in William Street is 32dBA to 34dBA. Maximum levels of around 41dBA can be expected.

The most stringent project-specific noise limit for William Street receivers is $L_{Aeq,15min}$ 40dBA during the night time. Sporting events, and other ancillary usage of the Sports Hall will achieve the recommended criteria for environmental noise emissions during all operational periods.

4.3.2 Pool Hall

The proposed new Pool Hall will replace the existing outdoor 25m pool. As such, operational noise associated with aquatic events are generally expected to reduce at surrounding receivers, although the new facility will enable additional activities and events previously held at other venues, to be held at the College. The building will comprise a combination glass (fixed and operable louvres minimum 10.38mm laminate assumed), facebrick and metal panel facade construction and a metal deck roof.

In terms of operational noise, maximum reverberant sound pressure levels of around 85dBA can be expected to be reached during large swim meets with contributions from spectators and participants calling out, PA etc. An L_{Aeq} over 15 minutes of around 76dBA (reverberant sound pressure level) is typical within similar aquatic facilities under general usage.

In order to assess the potential operational noise emissions from the proposed Pool Hall, a large attendance, competitive event has been adopted as representative of a worst case operational scenario. The emissions during typical College usage conditions (training, PE, school sport and casual use) have also been predicted.

The facility is located centrally within the College, between the proposed Sports Hall and the Barry Boarding and House Masters Houses. The southern elevation (facing towards Hunter Crescent) is exposed to the residential apartments at the western end of Hunter Crescent. The construction of this facade includes fixed glazing with operable louvres at high level.

The eastern elevation also includes high level operable louvres and glazed door openings into the pool deck from the marshalling area.

When used in competition mode, with a reverberant sound pressure level of 85dBA within the Pool Hall and the louvres on the southern and eastern elevations open, an $L_{Aeq,15min}$ of around 60dBA is predicted at the potentially most exposed residential apartments in Hunter Crescent. An $L_{Aeq,15min}$ of around 33dBA is predicted with the louvres closed. An $L_{Aeq,15min}$ of around 50dBA is predicted with the louvres on the southern elevation closed but all louvres and doors open on the eastern elevation.

Under typical daily College usage, with a reverberant sound pressure level of 76dBA within the Pool Hall and the louvres on the southern and eastern elevation open, an $L_{Aeq,15min}$ of around 50dBA is predicted at the potentially most exposed residential apartments in Hunter Crescent. An $L_{Aeq,15min}$ of around 26dBA is predicted with the louvres closed. An $L_{Aeq,15min}$ of around 43dBA is predicted with the louvres on the southern elevation closed but all louvres and doors open on the eastern elevation.

The project-specific noise limits for Hunter Crescent receivers is $L_{Aeq,15min}$ 50dBA during the daytime (7.00am-6.00pm), 45dBA during the evening (6.00pm-10.00pm) and 48dBA for the morning shoulder period (6.00am-7.00am). Normal daily usage of the Pool Hall will comply with the daytime citerion with the louvres on the southern and eastern elevations open. To achieve the recommended criteria at the nearest residential receivers in Hunter Crescent during early morning (shoulder) and evening usage, the louvres on the southern elevation are required to remain closed. Doors and louvres on the eastern elevation can remain open. The southern elevation louvres shall also remain closed during large-scale competitions to achieve the recommended criteria for environmental noise emissions during the daytime and evening periods. Doors and louvres on the eastern elevation can remain open. These results are summarised in Table 4-4.

Table 4-4 Predicted Operational Noise – Pool Hall

Operational Mode	Southern Louvres	Eastern Doors & Louvres	$L_{Aeq,15min}$	Project-Specific Noise Limit		
				Day	Shoulder	Evening
Typical Usage	Open	Open	50dBA	50dBA	48dBA	45dBA
Typical Usage	Closed	Open	43dBA	50dBA	48dBA	45dBA
Typical Usage	Closed	Closed	26dBA	50dBA	48dBA	45dBA
Competition (Swim meet)	Open	Open	60dBA	50dBA	48dBA	45dBA
Competition (Swim meet)	Closed	Open	50dBA	50dBA	48dBA	45dBA
Competition (Swim meet)	Closed	Closed	33dBA	50dBA	48dBA	45dBA

6 SUMMARY OF RECOMMENDATIONS

Based on our investigations of the project, the following findings have been determined.

6.1 Construction Noise Management Levels

Noise objectives for construction have been established based on EPA guidelines. The noise management levels should be adopted as objectives to work toward in minimising any noise impact at surrounding residences.

Table 6-1 presents applicable noise management levels at residential receivers in the vicinity of the site.

Table 6-1 Site Specific Construction Noise Management Levels – dBA

Area	Construction Noise Management Level, L_{Aeq} – dBA				Highly noise affected Noise Level, L_{Aeq} dBA
	Day	Evening	Night	Saturday*	
A – William Street	59	49	44	54	75
B – Hunter Crescent	55	48	46	50	75
C – Union Street**	55	48	46	50	75

* Extended Saturday construction hours.
** The lower noise criteria have been applied at residences on Union Street.

6.2 Construction Noise

It has been determined that noise from construction activities during the day period will potentially exceed established construction noise management levels. Therefore, the planning and management of construction activities must take into account the sensitivities of surrounding residents so as to minimise the impact of construction activities at these receivers.

The control of construction noise and vibration should be addressed in a Noise & Vibration Management Plan developed when the successful contractor has been appointed for the project.

The following project-specific mitigation measures are recommended;

- Selection of quietest feasible construction equipment;
- A 2.4m plywood hoarding around the construction site;
- Use of rock saws and ripping in preference to rock breakers;
- Localised treatment, such as barriers, shrouds and the like around fixed plant, such as pumps, generators and concrete pumps; and
- Provision of respite periods, particularly on Saturdays.

In the case of potential vibration, the following measures are recommended:

- Use rock saws in lieu of rock breaker or alternatively use smaller rock breakers in the eastern side of the site;
- Conduct trail vibration testing prior to use of rock breakers when near the eastern site boundary; and
- Assessment of vibration impact on the rail easement and selection of appropriate distance and equipment to be used in excavation in the vicinity of the rail easement.

6.3 Operational Noise

Site-specific noise criteria for the development have been established based on the lower of intrusive and amenity noise criteria.

The applicable operational noise levels at residential and commercial receivers in the vicinity of the site are presented in Table 6-2.

Table 6-2 Project-Specific Noise Criteria

Site	Site-Specific Noise Criteria $L_{Aeq,15min}$ (dBA)			
	Daytime 7am-6pm	Evening 6pm-10pm	Night Time 10pm-7am	Morning Shoulder 6am-7am
A – William Street	54	45	40	47
B – Hunter Crescent	50	45	40	48
C – Union Street	50	45	40	48
Commercial Receivers	65	65	65	65

Mechanical plant, such as carpark exhaust fans, rooftop exhausts, and cooling towers associated with the development should be assessed at the time of detailed design and selection, having regard to nearby residential and commercial properties surrounding the development, and to future uses in the school area.

To mitigate noise from mechanical plant, silencers could be incorporated in the outlets of the exhaust fans. Cooling towers with low noise fans can be specified within an acoustically-treated enclosure. Silencers can be installed to the fans if required. The mechanical plant noise emission would be designed to meet the criteria present in Table 5-2 at the closest receivers.

7 CONCLUSION

A construction and operational noise and vibration assessment of Shore Physical Education Centre North Sydney has been conducted. Site-specific noise criteria that are applicable to this entire project have been presented.

A noise assessment has been conducted for the proposed construction activities associated with the development to determine the potential for noise and vibration impact at surrounding receivers. Exceedances of noise management levels are expected at many surrounding receivers.

Vibration associated with on-site construction activities has the potential to impact on residences to the east of the site should large equipment, such as rock breakers be used. Trial monitoring and selection of less vibration intensive equipment is recommended.

Accordingly, management of noise from construction activities will be required to be included in the Site Construction Environmental Management Plan.

Site-specific operational noise criteria have been determined for the project based on ambient noise monitoring. A review of major plant indicates that noise levels will comply with established noise criteria during proposed operation with the inclusion of acoustic treatment. A review of all plant with respect to site specific noise criteria is required at detailed design stage. Operational noise emissions from the proposed Sports Hall will achieve the site specific assessment criteria under all operational modes. Operational noise emissions from the Pool Hall will comply with the site specific assessment criteria under typical College usage. During competitive swim meets, it is recommended that operable louvres on the southern elevation remain closed.

APPENDIX A

NOISE MEASUREMENT RESULTS

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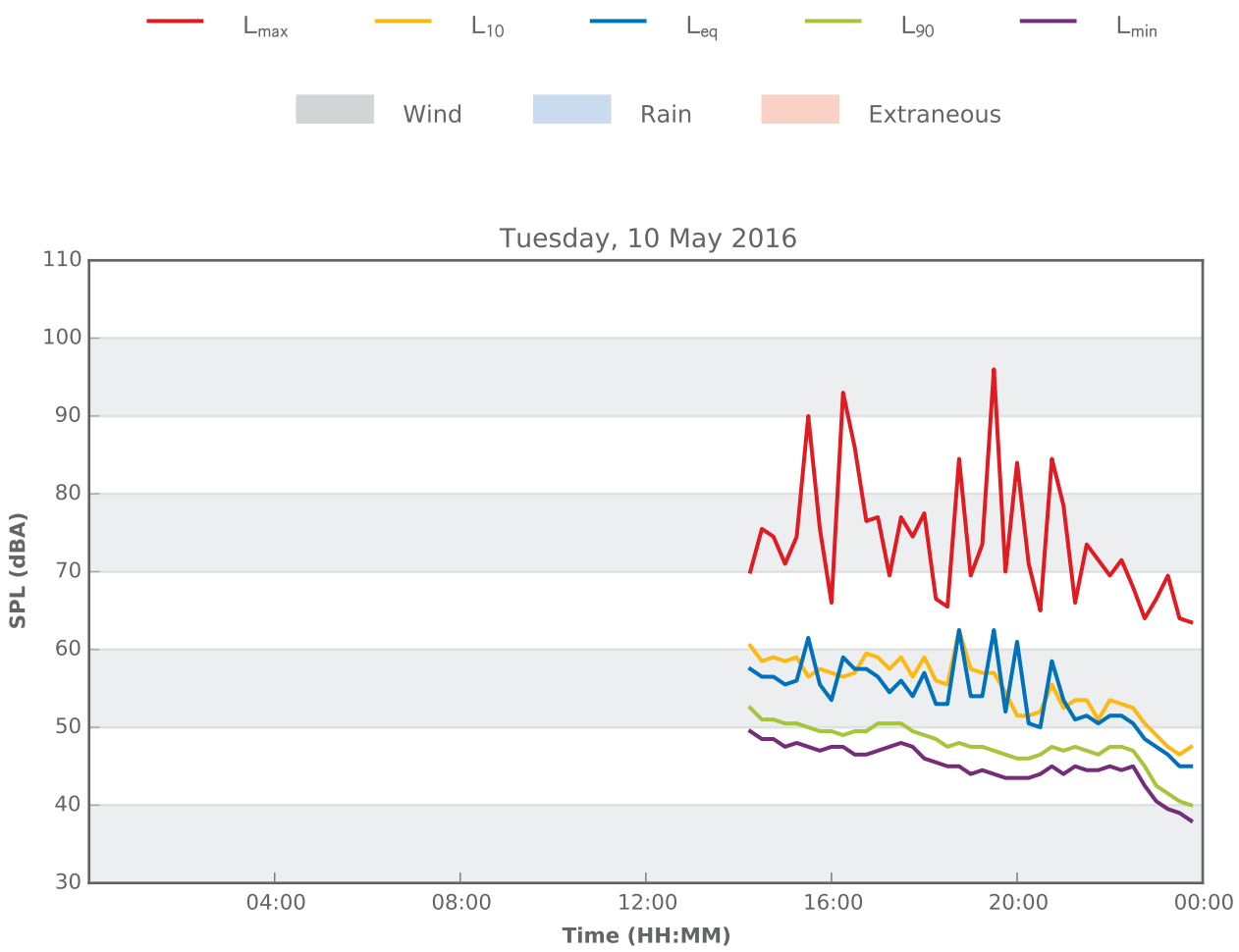

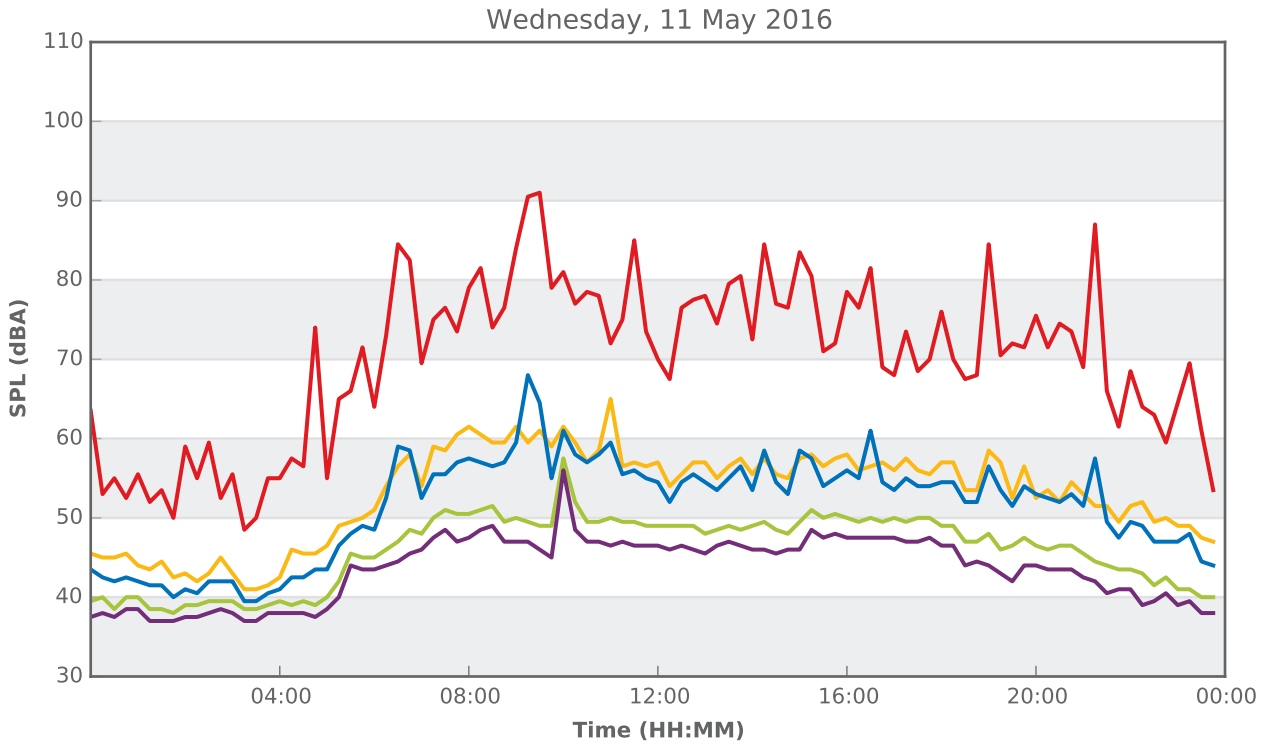

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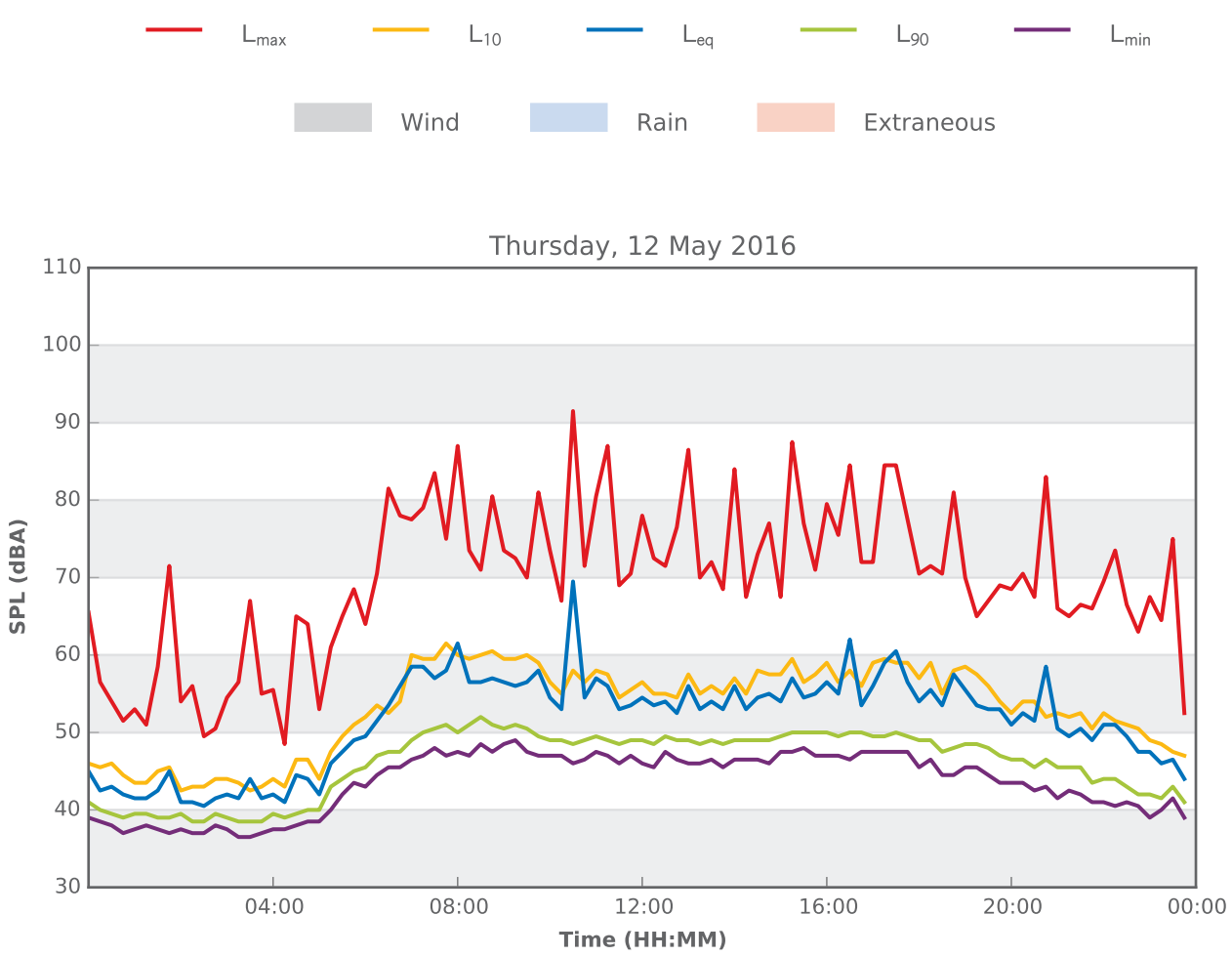

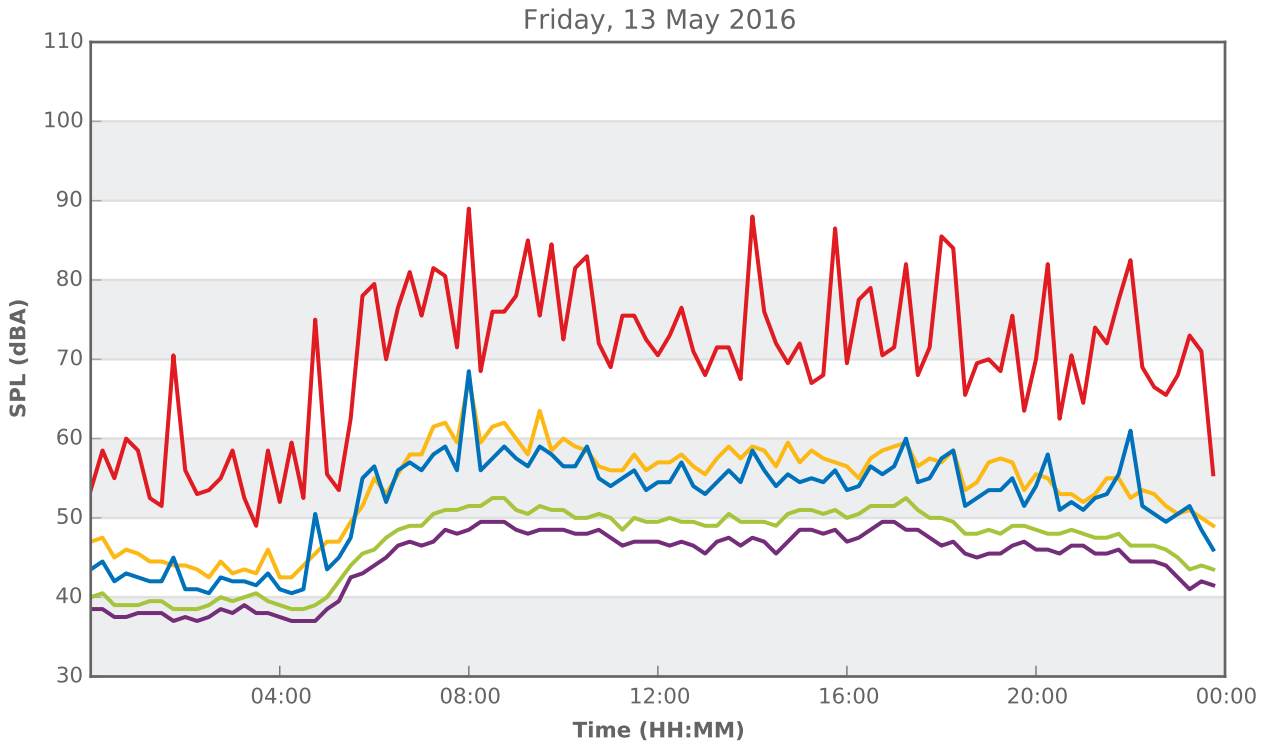

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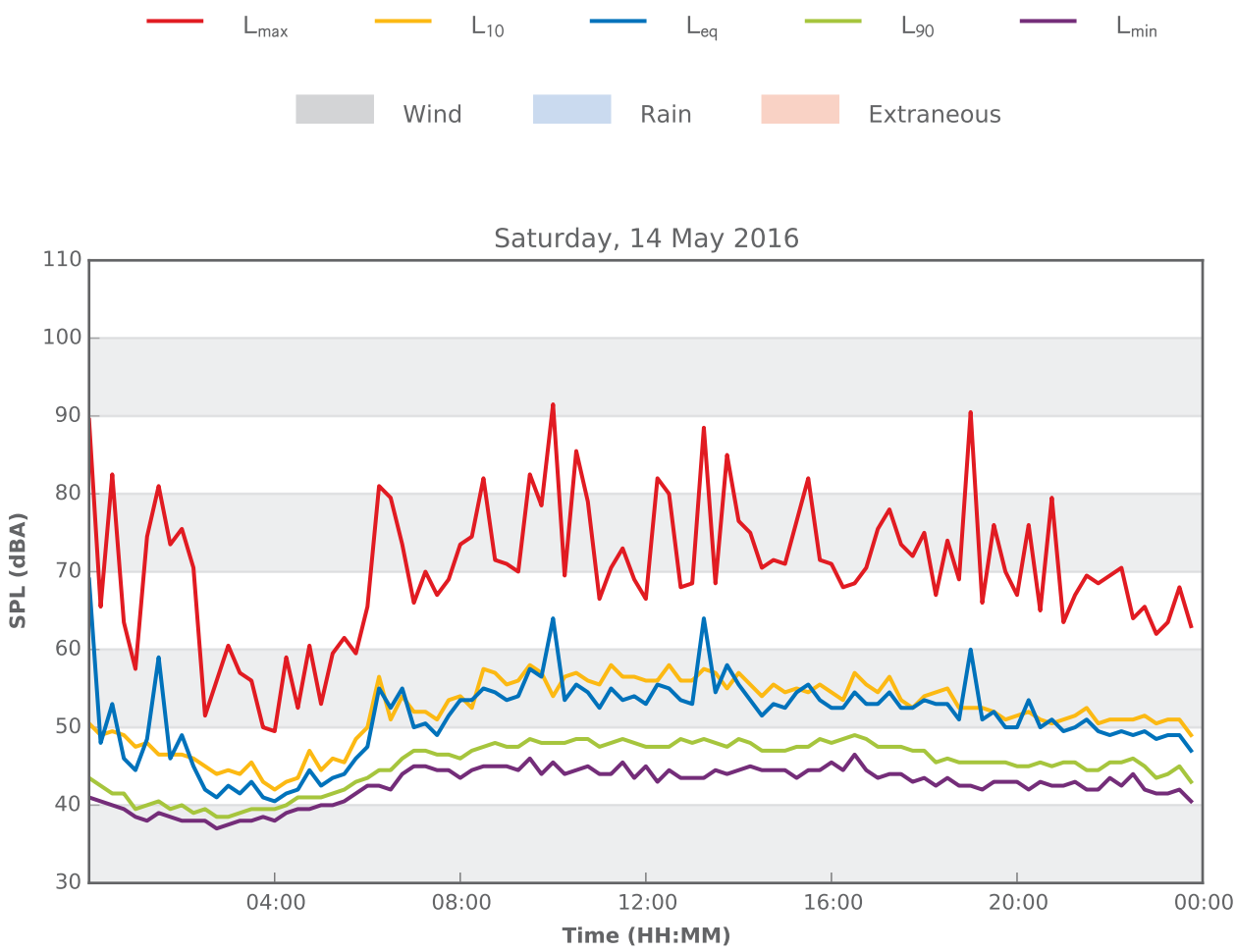

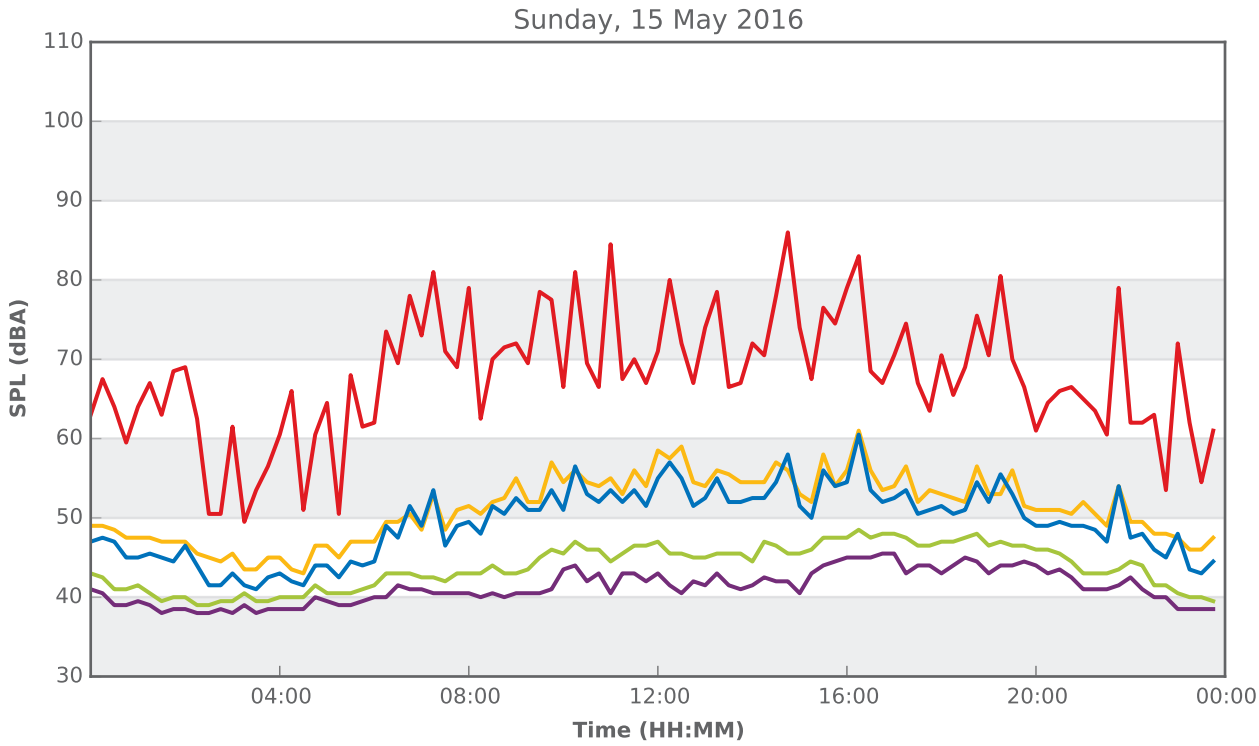

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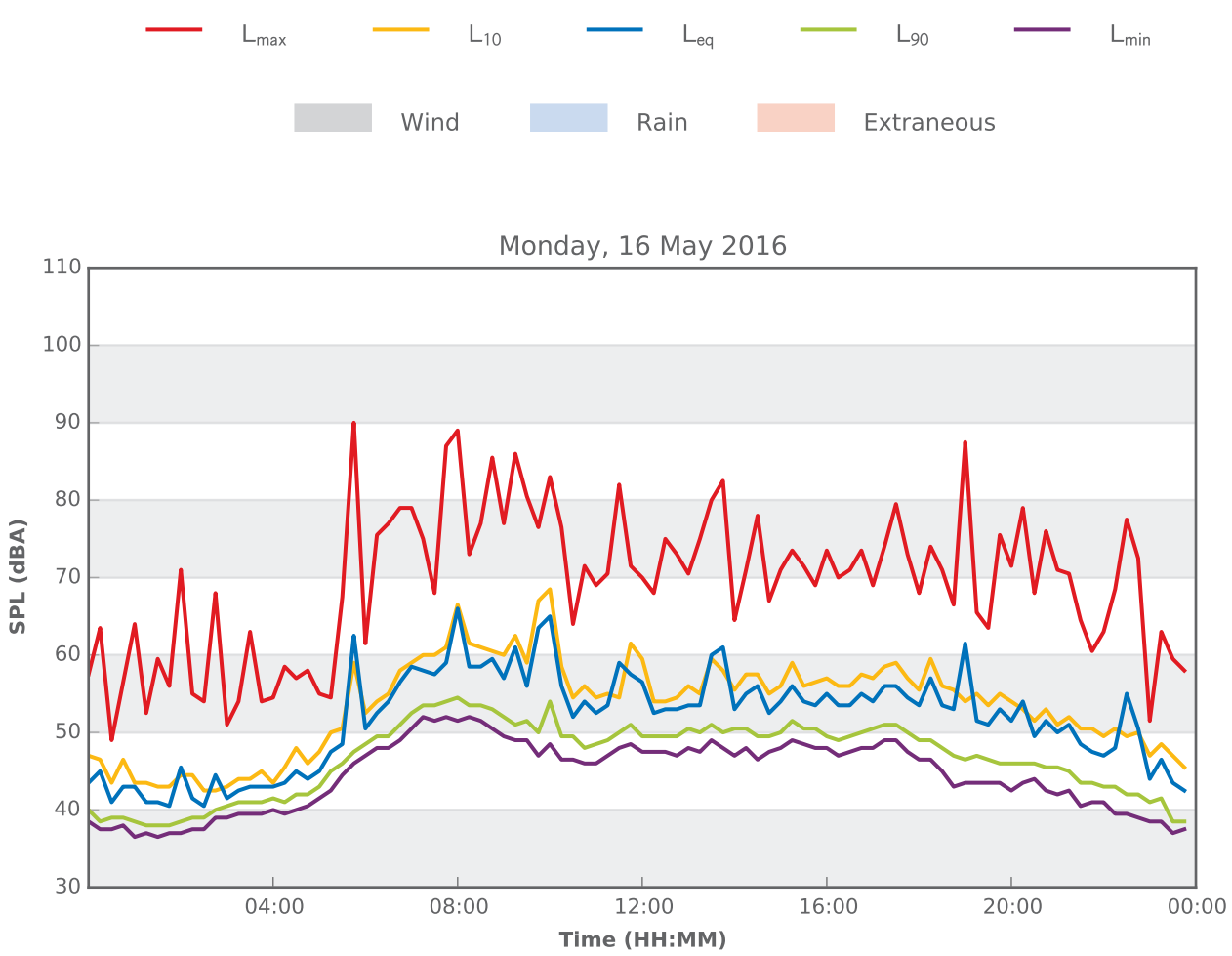

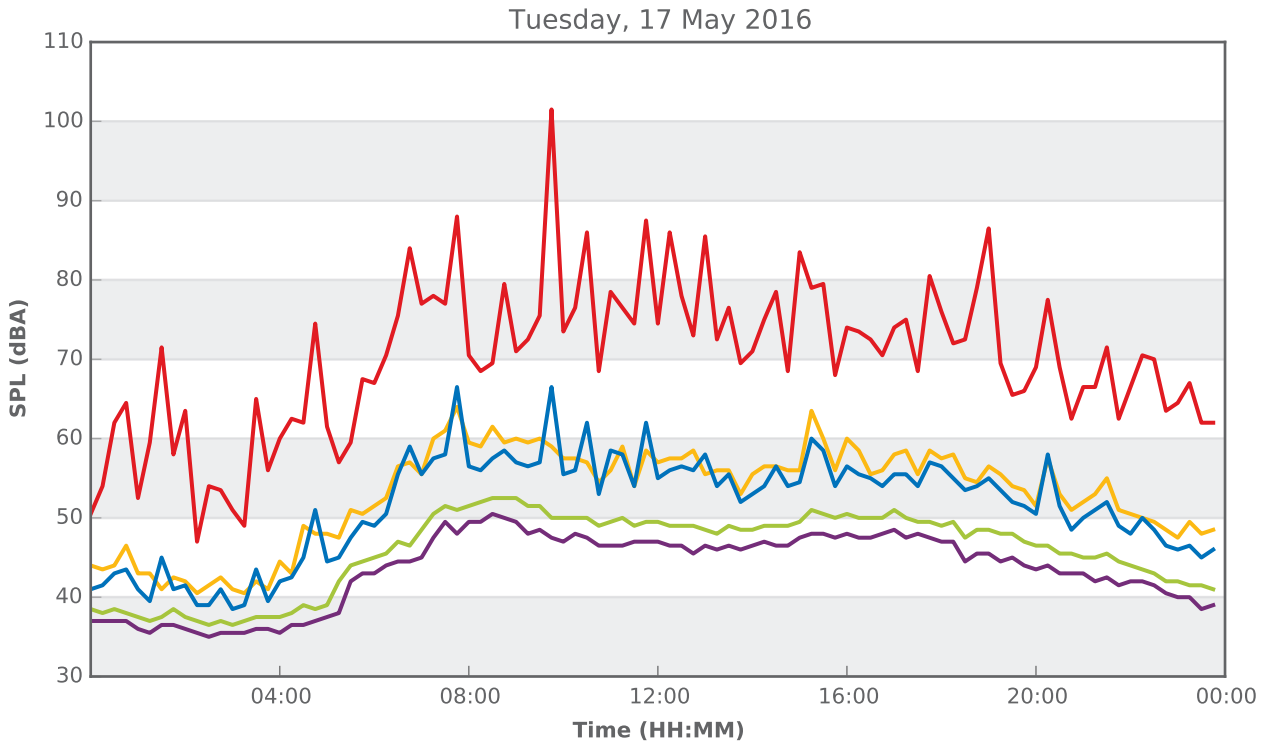

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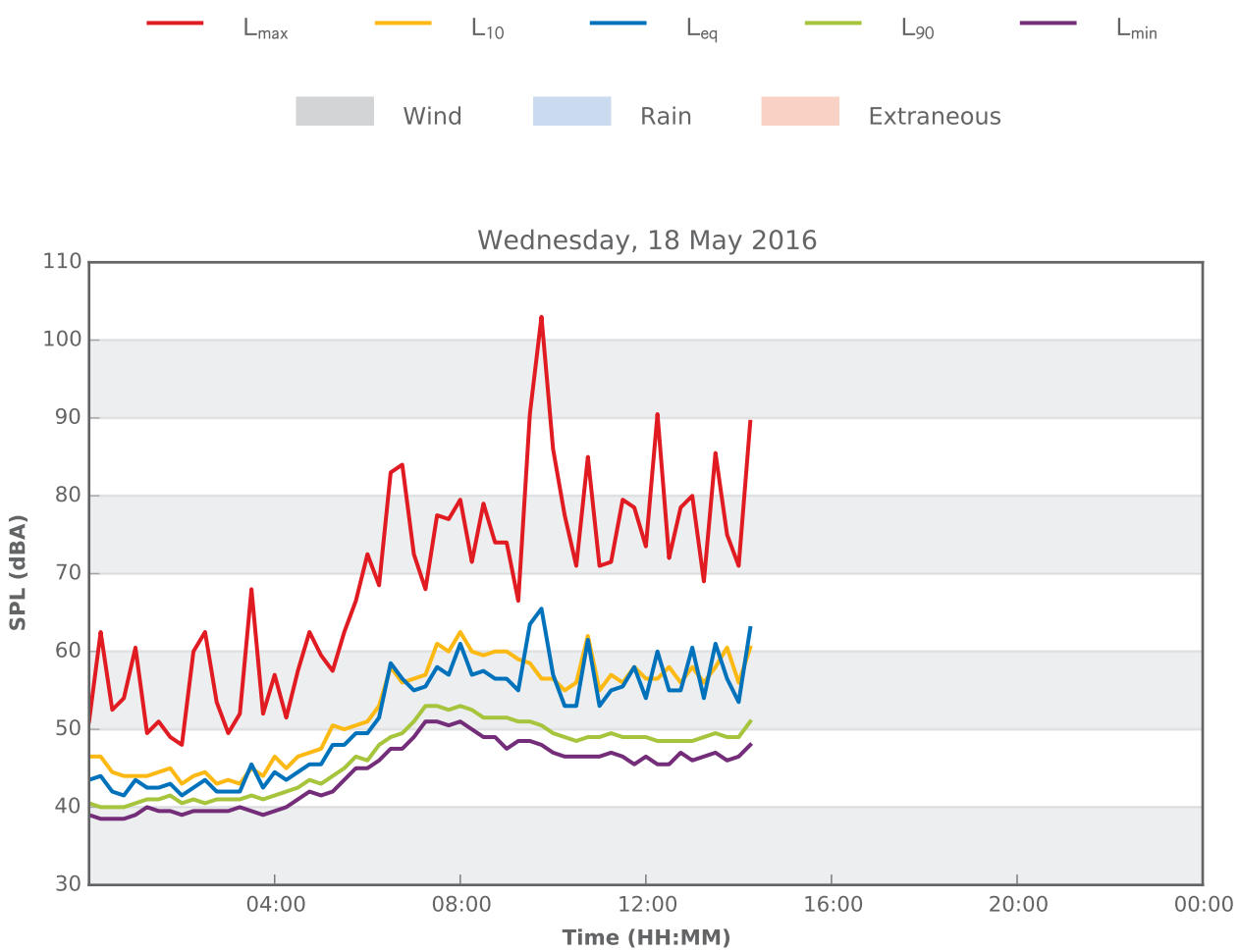

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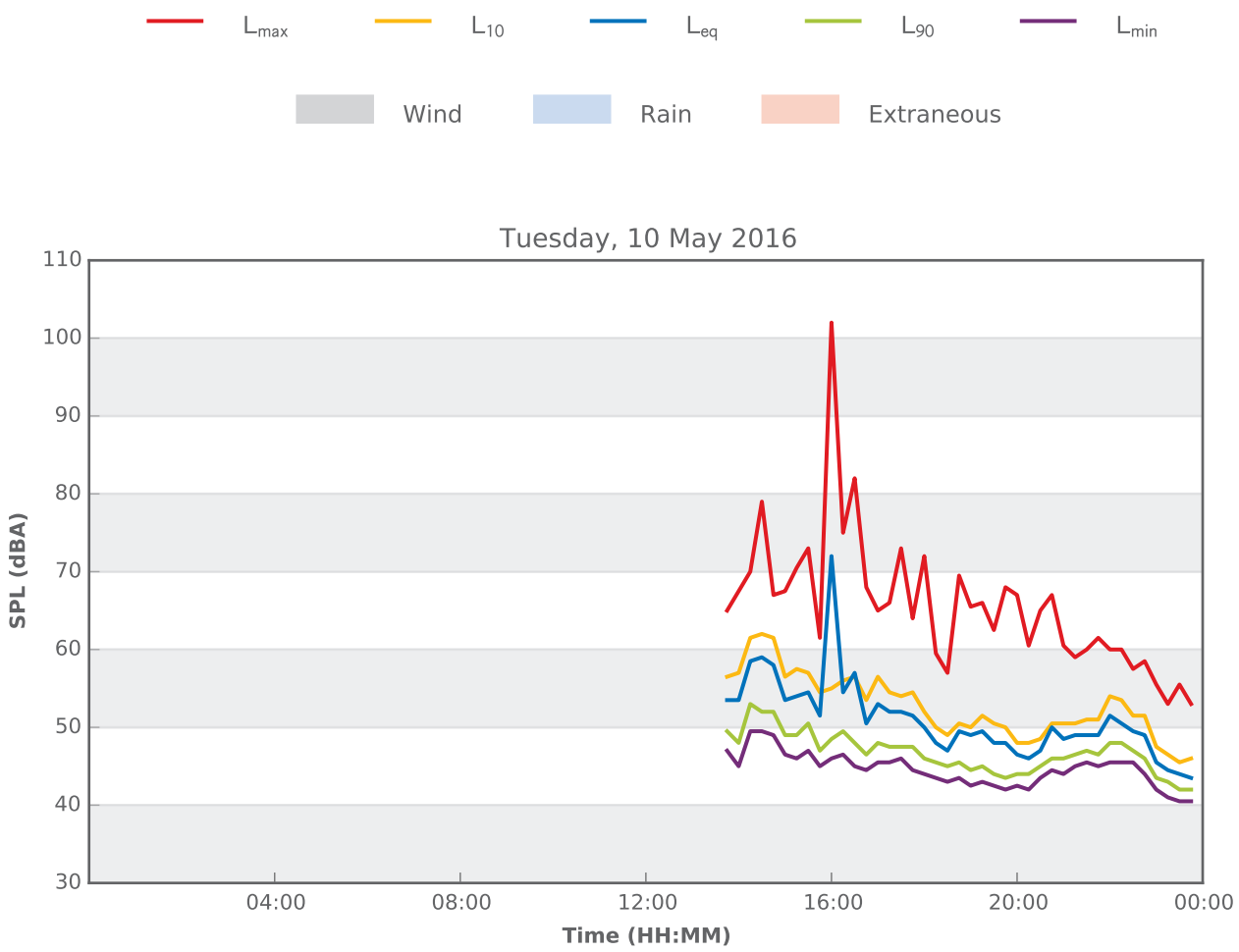

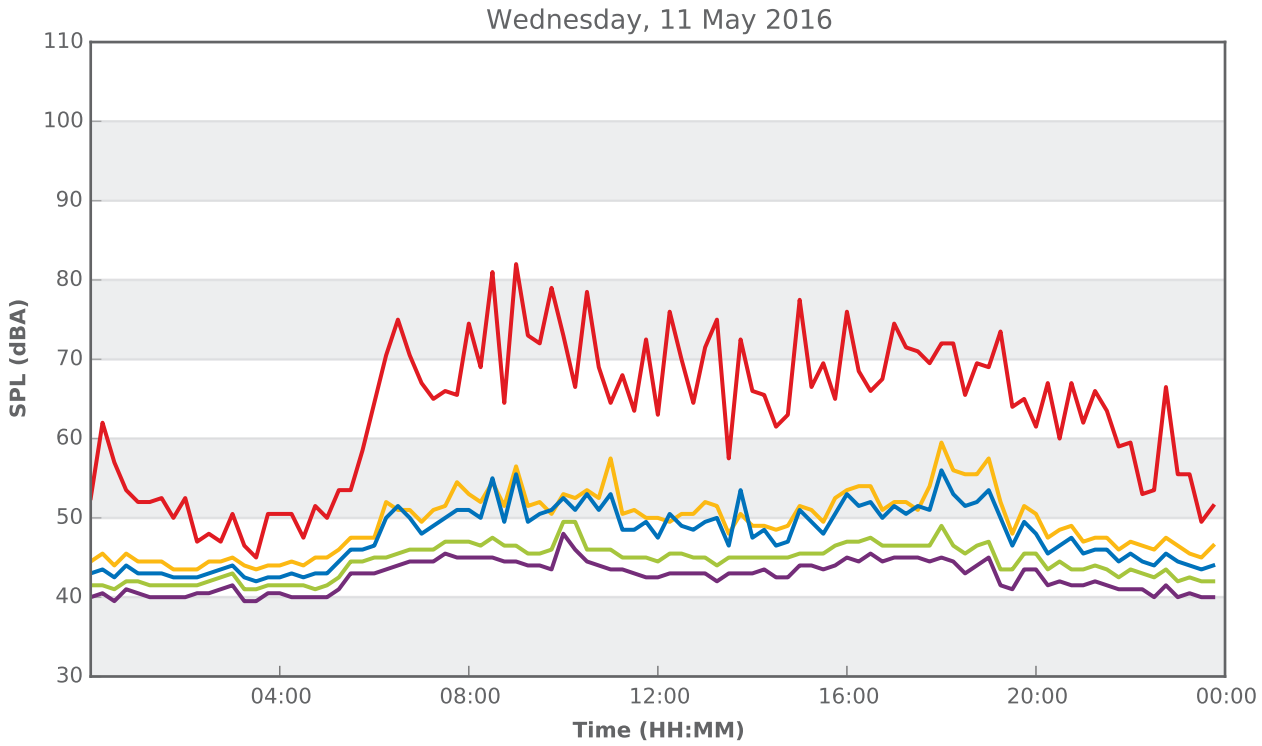

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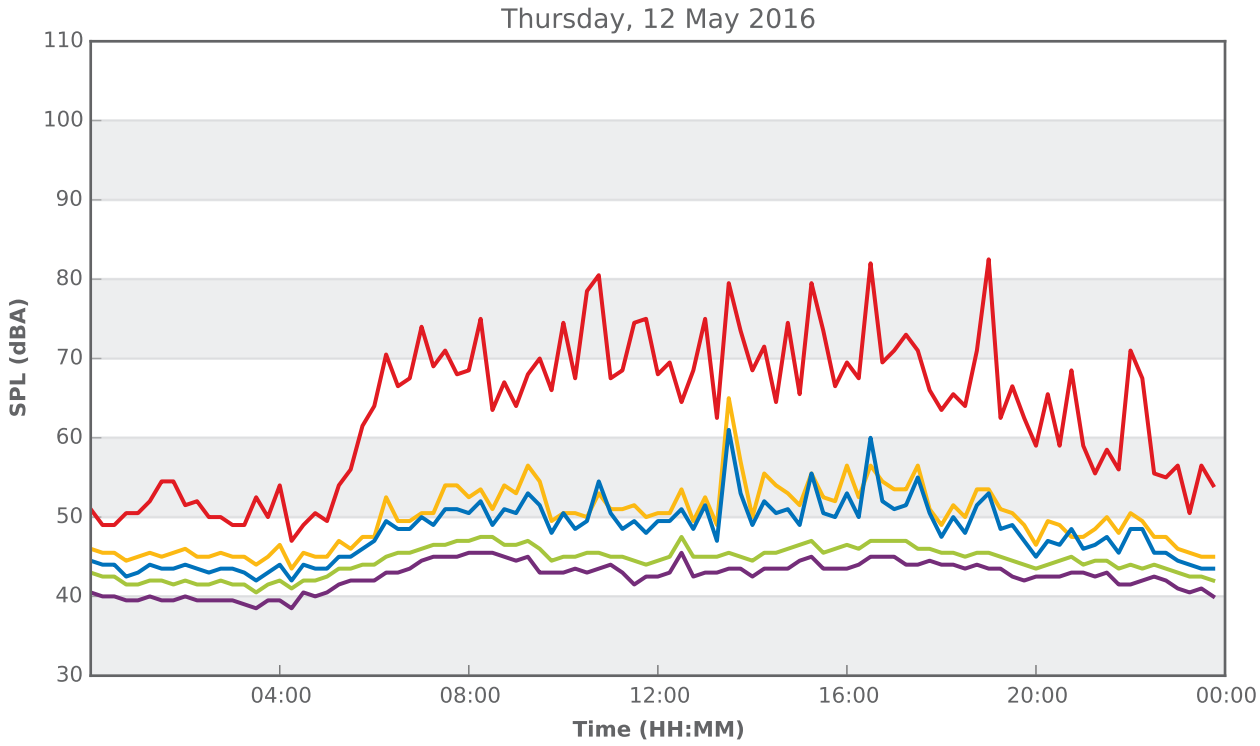

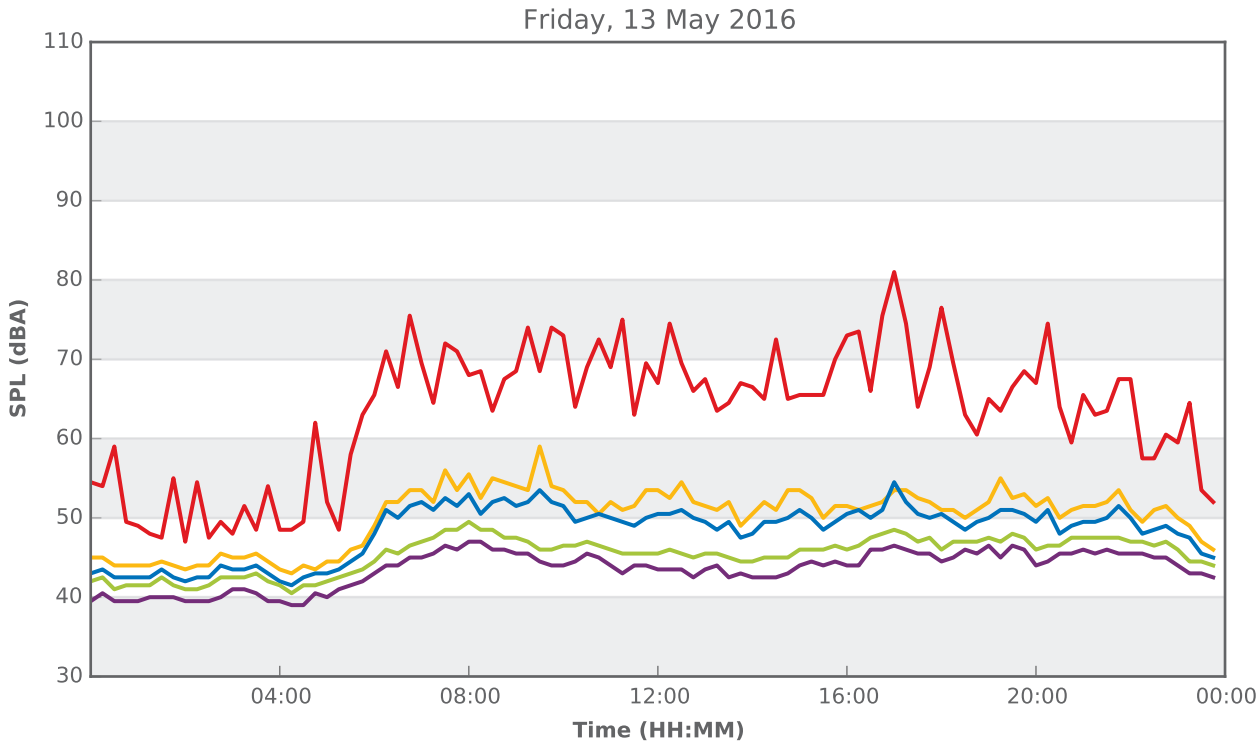

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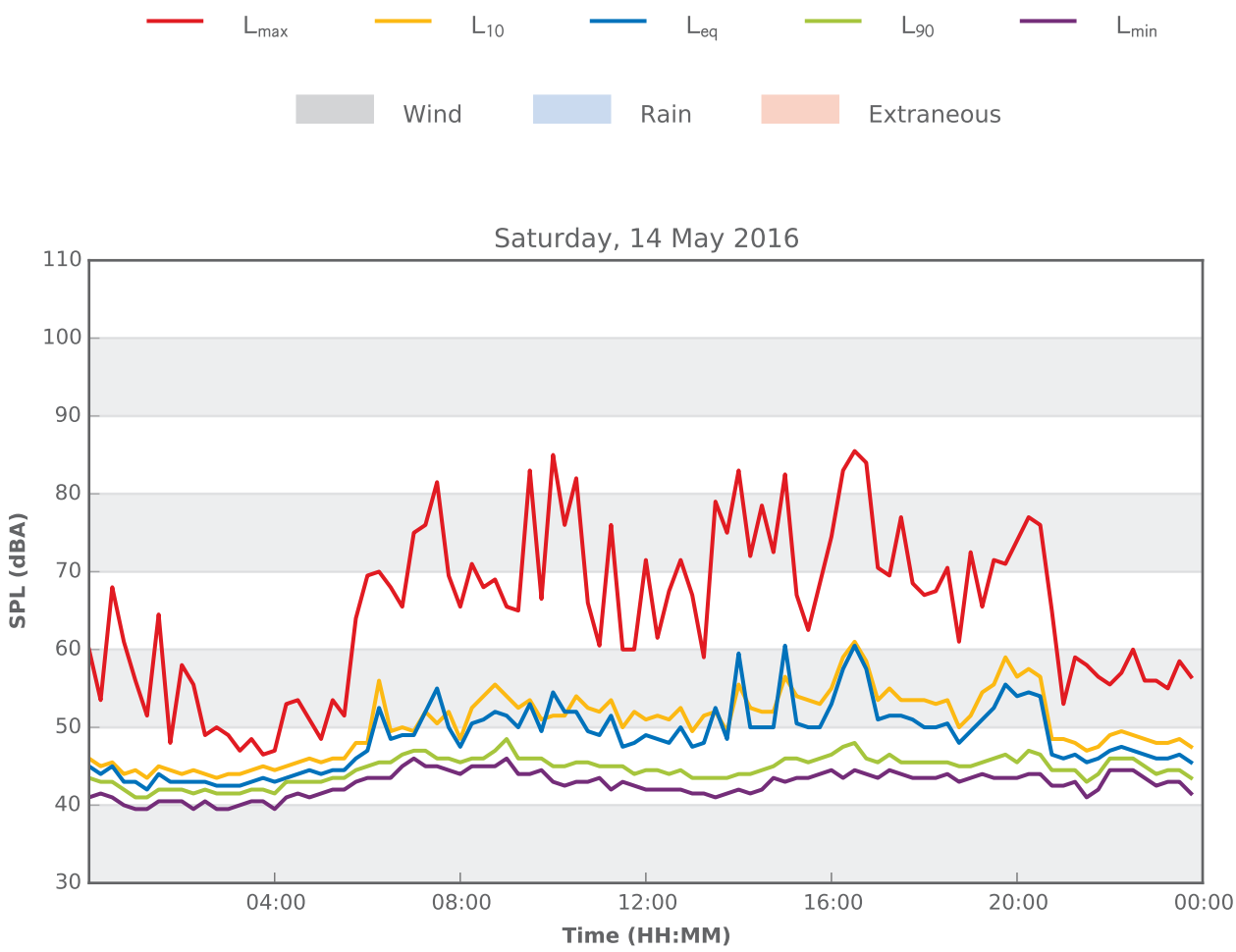

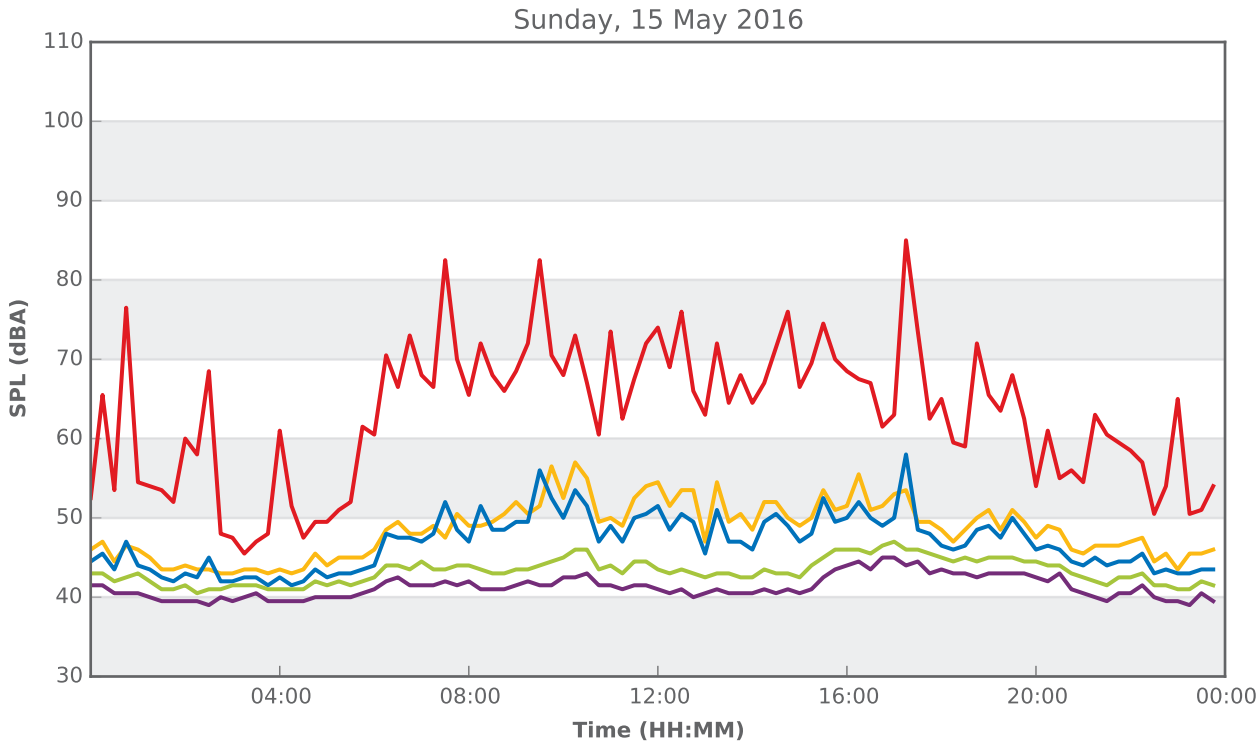

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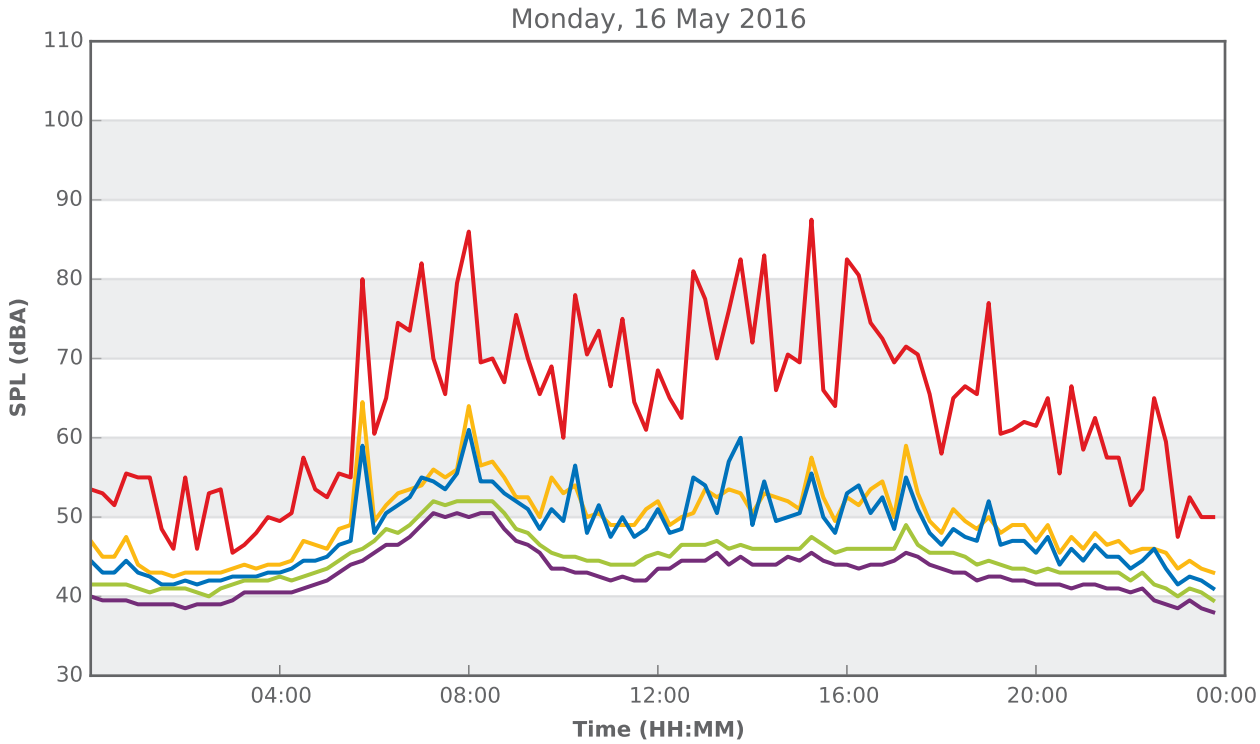

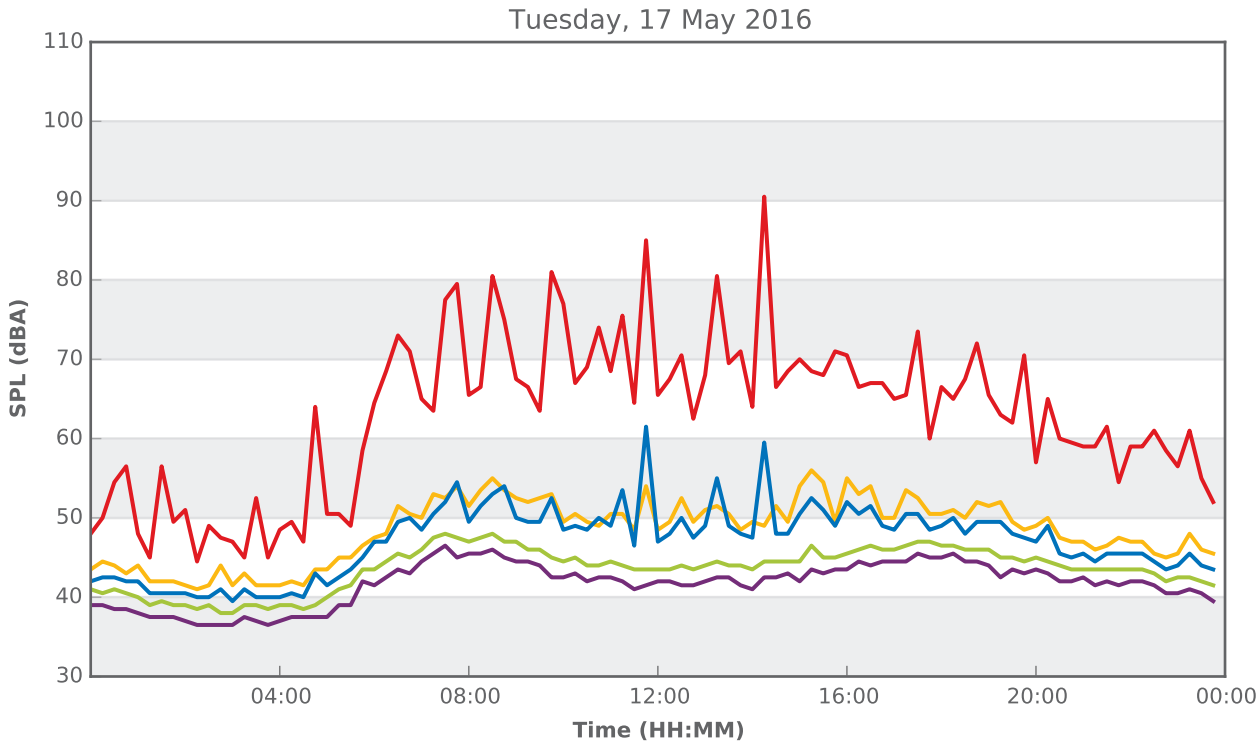

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